AN ANALYSIS OF FASCIOCUTANEOUS FLAPS AT VARIOUS STAGES OF COVER OF OPEN TIBIAL FRACTURES

Dissertation submitted in partial fulfillment of the requirements for the degree of

M.Ch. (Plastic Surgery) - Branch III

THE TAMIL NADU DR. M.G.R. MEDICAL UNIVERSITY
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DECLARATION

I, Dr. J. Pablo Neruda solemnly declare that the dissertation titled "AN ANALYSIS OF FASCIOCUTANEOUS FLAPS AT VARIOUS STAGES OF COVER OF OPEN TIBIAL FRACTURES", is a bonafide work done by me at Government General Hospital and Madras Medical College during 2004-2007 under the guidance and supervision of my Chief. Prof. M.P. Namasivayam M.S. M.Ch.

The dissertation is submitted to the Tamil Nadu Dr. M.G.R. Medical University, towards partial fulfilment of the requirement for the award of M.Ch. Degree (Branch – III) in Plastic Surgery.

Place: Chennai
Date:

Dr. J. PABLO NERUDA

CERTIFICATE

This is to certify that the dissertation titled 'AN ANALYSIS OF FASCIOCUTANEOUS FLAPS AT VARIOUS STAGES OF COVER OF OPEN TIBIAL FRACTURES' of Dr.J. PABLO NERUDA, in partial fulfillment of the requirements for M.Ch. Branch – III (Plastic Surgery) Examination of the Tamil Nadu Dr. M.G.R Medical University to be held in August 2007 is bonafide. The period of study was from August 2004 to January 2007.

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CONTENTS

INTRODUCTION

Coverage of open tibial fractures presents unique defects requiring the ingenuity of the surgeon in devising flaps for stable coverage.

In our country road traffic accidents are the most common cause of lower limb trauma, followed by fall from height.

Though well established norms are in place regarding the time and nature of cover, it requires a team effort with involvement of the orthopaedic surgeon as a rule, and allied specialities like vascular surgeons, general surgeons.

Despite stable fixation being obtained earlier, the timing of soft tissue cover varies owing to several factors like availability of reconstruction team, doubtful vascularity, skill of the attending surgeon, concomittant injuries to the lower limb, comorbid factors, prolonged anaesthesia time etc.

Though Free tissue transfer has revolutionised coverage of leg defects it may not be feasible to have the personnel with the necessary skill at that time.

Fasciocutaneous flaps and Muscle flaps still have well established roles to play in extremity reconstruction.

Plastic surgery becomes not only important in covering a raw area, but also in providing a functional limb with an acceptable aesthetic result.

Though we live in an era of zero delay work, microvascular transfer and a single stage work up, often owing to circumstances beyond our control, it may still be necessary to revisit the older methods which are reliable, comparable and easily reproduced.

Thus it is imperative to enhance our quality of work in those areas to produce a good result with a few complications as possible. It is with this idea that the study was done.

Just as the dogma that skin flap survival depends on rigid length to width ratios has been refuted, the generalisation that distally based flaps are inferior to proximally based flaps also deserves to be challenged. All else being equal, the truly critical factor of flap viability in either case is the nature of their intrinsic blood supply rather than any arbitary orientation or configuration.

After Ponten's reintroduction of the fasciocutaneous flap principle, the accumulated experience has proved its simplicity, availability, versatility and dependability, even as the initial local flap alternative in lieu of sacrificing a muscle, that might be only be marginally expendable, or perhaps to avoid the complexity of a microsurgical tissue transfer. Fasciocutaneous flaps are particularly applicable for small, uncontaminated defects where more complicated solutions should be considered unjustifiable.

The 'Superflaps' of Ponten had a longitudinal orientation, and their circulation entered the proximal margin of the flap. Soon thereafter, the advantages of capturing these proximal skin territories by a flap, based on perforators nourishing the same fascial plexus, but entering via the most distant boundary, became obvious for coverage extending even to the most distal part of an extremity.

The preconceived notion that superiorly based flaps are superior to inferiorly based flaps has been disproved by Hallock who in his study found that, the inclusion of a dominant source vessel, its perforators to a given skin territory, their interconnected choke vessels, and the resulting span of the adjacent captured link are the actual major determinants predicting flap survival and not the orientation of the flap pedicle perse.

There are several unique situations in which overall risk of flap failure may be minimised by the selection of a proximally based flap. Because arterials gradients, especially in the dysvascular patient, diminish toward the periphery, reverse perfusion may be inadequate to capture a proximal territory, whereas the converse may not be true.

Venous valves in the lower extremity tend to be thicker, less pliable, and more competent because of their routine exposure to greater hydrostatic pressures, so that distally based flaps tend to be riskier if venous outflow must depend on retrograde regurgitation.

Thus if only a proximally based flap is chosen, the great potential of distally based flaps for coverage of the most acral portion of the extremity, where other local flaps don't exist will be overlooked. In addition, because the resulting donor site could be located proximally, usually overlying muscles, the donor site morbidity is actually less than that of a proximally based flap.

One must always consider the patients expectations, recognition of local anatomical constraints, and an understanding of the quality of existing source vessels to the fascial plexus in the given region. If these prerequisites for any local fasciocutaneous flap, cannot be satisfied, other alternatives should take precedence

AIM

1. To analyze fasciocutaneous flap reliability in coverage of open tibial fractures.

2. To analyze the complication rates of fasciocutaneous flaps at various phases of wound; Acute, subacute and chronic.

3. To compare the complication rates and ultimate wound coverage rates of fasciocutaneous flaps with free flaps from other series.

4. To compare proximally versus distally based fasciocutaneous flaps complication rates.

5. To establish a definitive time based protocol for fasciocutaneous flaps at Government General Hospital for open tibial fractures.

MATERIALS AND METHODS

This study was conducted in the Department of Plastic Surgery, Government General Hospital and Madras Medical College over a period of 30 months Aug 2004 to Jan 2007.

Only cases with post-traumatic open tibial fractures were included.

Only patients with fasciocutaneous flap covers were chosen .A total of 74 patients were included in the study.

Timing of coverage was classified into

Acute - within 72 hours

Subacute - 3 days to 6 weeks

Chronic - Greater than 6 weeks

All patients were assessed with a thorough history, clinical examination, type of orthopaedic intervention and co-morbid illnesses.

All patients, in addition to routine investigations were submitted to Xray of the local part and Doppler examination of the peripheral pulses and perforators.

In infected cases, seen late, they were already on appropriate antibiotics after culture and sensitivity.

In Acute situations where immediate cover was done, the wound was debrided by the Plastic surgeon prior to skeletal fixation.

In other cases wounds were debrided initially by the orthopaedic team and again during the cover by the plastic surgeons.

Defects were classified according to their site as per the usual norms of upperthird, midthird and lower third.

All patients were retained in the plastic surgical ward till the flap had healed completely.

Follow up periods varied with the individual's compliance.

SURGICAL ANATOMY OF THE LEG

The leg can be divided into four compartments

A. Anterior compartment

This consists of the following muscles.

1. Tibialis Anterior

2. Extensor Hallucis Longus

3. Extensor Digitorum Longus

4. Peroneus Tertius.

The artery of the anterior compartment is the anterior tibial artery. The nerve is the Deep peroneal nerve.

B. Lateral compartment

Muscles include

1. Peroneus Longus

2. Peroneus Brevis.

The artery(s) of this compartment are peroneal artery and anterior tibial artery. The never is superficial peroneal nerve.

C. Superficial posterior compartment

Muscles include

1. Gastrocnemius

2. Soleus

3. Plantaris

4. Popliteus

The artery(s) are sural, peroneal and posterior tibial.

The nerve is the tibial nerve.

D. Deep posterior compartment

Muscles include

1. Flexor hallucis longus

2. Flexor digitorum longus

3. Tibialis posterior

The arteries are peroneal and posterior tibial.

The nerve is tibial nerve.

ANGIOSOMES OF THE LEG

A study by Taylor has shown that connections between adjacent angiosomes occured within tissues and not between them. The skin, muscles and bones received branches from 2 or more angiosomes, thus showing important anastamotic pathways through which circulation is reconstituted when a source artery is interrupted.

The results for the skin showed that cutaneous vessels arise from source arteries or their muscle branches, they pierce the deep fascia in longitudinal rows in the vicinity of the intermuscular septa or beside the tendons. During their course they supply branches to each tissue they pass, whether bone, muscle, nerve, tendon or fascia. After piercing the fascia their branches radiate in all directions, being longest where they are related to the cutaneous nerves or where the skin is mobile, ultimately interconnecting to form a vascular network within the integument.

The angiosomes of the leg are the popliteal, descending genicular, sural, peroneal, anterior tibial and posterior tibial.

Over the subcutaneous surface of the tibia where the skin is fixed, the deep fascia is continuous with the periosteum of the bone. Branches of the anterior tibial and posterior tibial arteries anastamose over the surface of the periosteum and it is here that their supply to the overlying skin is easily torn by shearing forces. Five rigid fascial envelopes encase the muscles and other deep tissues of the leg. The source arteries and their venae commitantes

travel adjacent to, but not within these walls, but in loose connective tissue to one side of the fascial sheet.

Blood supply to the fasciocutaneous flaps are from 3 sources

1. Musculocutaneous perforators.

2. Axial vessels - saphenous artery and superficial sural artery.

3. Septocutaneous perforators for each of the anterior tibial, posterior tibial and peroneal vessels.

Location of septocutaneous perforators (Bhattacharya V. et al IJPS 2003)

Vessels Location	PTA (Distance from Medial Malleolus)	PA (Distance from LM/FH)	ATA
N1	4.5cm	4-10cm (LM)	2-4cm from origin of Anterior Tibial artery
N2	6.0cm	10-13 cm (LM)	
N3	9-12cm	15-20 cm (LM)	
N4	17-19cm	5-6 cm (FH)	
N5	22-24cm		

Code

N - Number of Preforator

LM - Lateral Malleolus

FH - Fibular Head

PTA - Posterior Tibial Artery

PA - Peroneal Artery

ATA - Anterior Tibial Artery

Preoperative Doppler study helps in locating the main vessel and the site of the perforators. A colour Doppler may provide additional information on the size of the vessel.

The size of the peroneal artery decreases proximo distally but the posterior tibial artery remains the same size.

Surface markings for the 3 main vessels are

A. Posterior tibial artery.

A reference line is drawn by joining the tibial tuberosity and the mid malleolar point. The vascular axis lies 4.5 cm medial and parallel to this line or 1.5 cm from medial border of tibia.

B. Anterior Tibial artery and Peroneal artery

Reference line is drawn by joining the head of the fibula and tip of the lateral malleolus. Anterior tibial artery axis lies 2.5 cm anterior and parallel to this line Peroneal artery axis lies 2.5 cm posterior and parallel to this line.

The perforators of the posterior tibial artery and peroneal artery are located at every 4-5 cm from tip of the malleoli In distally based flaps, the lower

limit of the dissection decides the reach of the flap. Since the two lower perforators are approximately within 8 cm from the malleoli, that is taken as the safe limit of dissection inferiorly.

Cormack and Lamberty also introduced a new classification

Type A - has a fascial plexus

Type B - has a single perforator

Type C - has multiple perforators and segmental source artery

Mathes and Nahai's Classification

Type A - with a direct cutaneous pedicle to the fascia

Type B - with a septocutaneous perforator

Type C - with peforators from a musculocutaneous source

Variants of Fasciocutaneous flaps

1. Antegrade (superiorly based)
2. Retrograde (inferiorly based)
3. Deepithelized turn over flaps
4. Islanded perforator based flaps
5. Fasciocutaneous with adipofascial extension

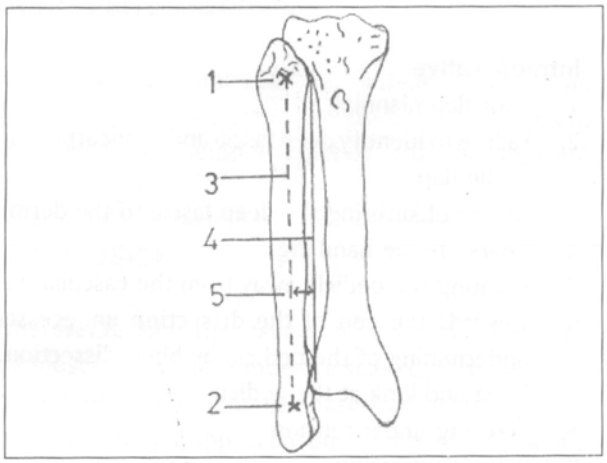


Figure 3: Vascular Axis of Anterior Tibial Artery

1. Head of Fibula
2. Tip of Lateral Malleolus
3. Reference Line
4. Vascular Axis
5. 2.5 Cm Anterior and Parallel

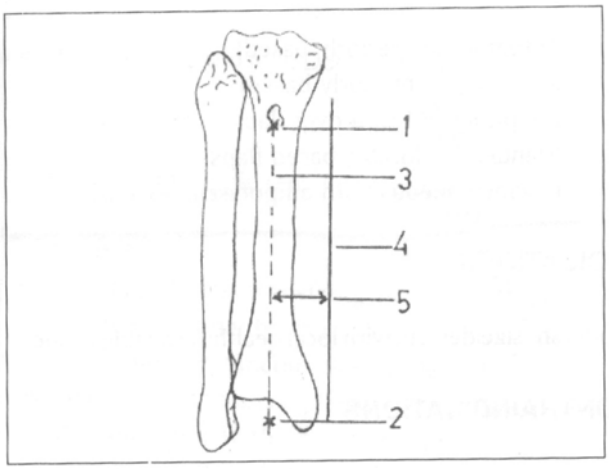


Figure 2: Vascular Axis of Posterior Tibial Artery

1. Tibial Tuberosity
2. Mid Malleolar Point
3. Reference Line
4. Vascular Axis
5. 4.5 Cm Medial and Parallel

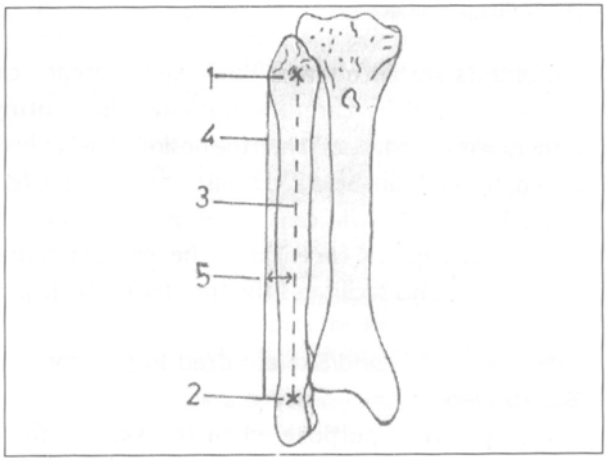


Figure 4: Vascular Axis of Peroneal Artery

1. Head of Fibula
2. Tip of Lateral Malleolus
3. Reference Line
4. Vascular Axis
5. 2.5 Cm Posterior and Parallel

CLASSIFICATION OF OPEN FRACTURES.

(GUSTILO ANDERSON)

Type I - Open fracture with a clean wound, < 1cm in length.

Type II - Open fracture with a laceration >1cm long and without extensive soft tissue damage, flaps or avulsion.

Type III - An open fracture with extensive soft tissue laceration, damage, or loss, an open segmental fracture; or a traumatic amputation.

High velocity gunshot injuries; open fractures caused by farm injuries; open fractures requiring vascular repair; open fractures older than 8 hours.

Type III - Subtype (1984)

A - Adequate periosteal cover of a fractured bone despite extensive soft tissue laceration or damage; high energy trauma irrespective of size of wound.

B - Extensive soft tissue loss with periosteal stripping and bone exposure, usually associated with massive contamination.

C - Associated arterial injury requiring repair, irrespective of degree of soft tissue injury

SURGICAL PRINCIPLES

Classification by Site

UPPER THIRD

MIDDLE THIRD

LOWER THIRD

Reconstructive options

1. Fasciocutaneous flaps
2. Muscle flap with split skin grafting
3. Myocutaneous flaps.
4. Crossleg flaps
5. Free flaps

Technique of Flap raising

All flaps were done under spinal anaesthesia, with pneumatic tourniquet control.

Flaps were marked preoperatively after planning in reverse

Dissection was begun distally taking care to suture the fascia to the dermis to prevent shear

After raising the appropriate length of the flap, it was transferred to the defect and inset given in a single layer with 3 '0' Ethilon after placing a

suction drain beneath the flap. Immoblisation was with a plaster of Paris slab if the external fixator was not sufficient.

Assessment of the region involved

Reconstruction of the lower extremity has traditionally been planned by dividing the leg in three parts. Flaps available in each third are then enumerated (eg. Gastrocnemius for the proximal third, soleus for the middle third, free tissue transfers or distally based flaps being reserved for the lower third of the leg). Although this traditional method can be useful, the surgeons must decide what is the optimal technique for the particular defect, not necessarily the most expeditious.

Soft tissue coverage of the leg defects

The time honoured concept of dividing the lower leg into three parts and deciding the type of pedicled flap required, remains useful, but must be subordinated by a more functional and aesthetic evaluation of the wound.

a. Skin grafts

Skin grafts are applicable only if there is a healthy vascular recepient bed or if the periosteum over the bone is intact.

b. Skin flaps

Local skin flaps like transportation, rotation and local advancement flaps are suitable only for small defects. Islanded skin flap from dorsum of

foot (based on dorsalis pedis vessels) may be used for defects around ankle joint including over malleoli and tendoachilles. Distant skin flaps like cross leg flap, abdominal tube pedicle flap and jump flap have become almost obsolete as they are staged procedures and are indicated for larger defects.

Fasciocutaneous flaps

Fasciocutaneous (FC) flaps have been well investigated and tried out in the leg defect. As early as in 1901, Pouteau reported the use of fasciocutaneous flaps in the lower leg. Taylor's work on the blood supply to the skin demonstrated that in the trunk it is usually musculocutaneous and in the limbs fasciocutaneous in nature. Ponten had shown that the flaps in the leg can measure 8cm x 18cm and can be raised in a single stage without necrosis if the deep fascia is included. FC flap may be used locally in the ipsilateral limb or distally as a cross leg FC flap.

The blood supply to fasciocutaneous flaps can be from three sources.

1. Musculocutaneous perforators: For example via gastrocnemius.
2. Axia vessels: Sephenous artery and superficial sural arteries
3. Septocutaneous perforators: For each of anterior tibial, posterior tibial vessels and peroneal vessels.

Numerous authors have attempted to study the location of septocutaneous perforators in relation to bony land marks and leg lengths.

Advantages of FC flaps

1. One stage procedure
2. Simple to execute
3. Gives a stable cover
4. If required, a portion of the flap can be deepethelized to obliterate a cavity.
5. The flap can be islanded.

Disadvantages of FC flaps

1. Donor site needs to be skin grafted,.
2. Unlike muscle flap, not suitable for filling infected cavities.

Selection of fasciocutaneous flaps for leg defects

a. Knee and upper third leg

Proximally based fasciocutaneous flap based on the perforators of the post tibial, anterior tibial or peroneal artery.

b. Middle third leg

Proximally based flaps on the posterior tibial or peroneal perforators or a distally based flap on the lower posterior tibial perforators.

c. Lower third leg

Distally based or cross leg fasciocutaneous flap may be used.

- Flaps based on Lower perforators of the post tibial and peroneal arteries.
- Reverse sural artery flap.
- Posterolateral malleolar flap
- Distally based fasciocutaneous flap

d. Adipofascial flaps

Adipofascial flaps have become extremely popular in the last decade in the reconstruction of lower leg defects. Adipofascial flaps are like fasciocutaneous flaps, as the vascular basis is same in both flaps. Gumener described distally based fasciosubcutaneous flaps to reconstruct soft tissue defect of lower leg and foot. Lin et al popularized the distally based medial adipofascial flaps to cover the exposed bones in the lower leg. These flaps are ideal for reconstruction of composite defects around the lower leg and ankle. Flaps are based on the posterior tibial, peroneal, anterior tibial vessels

and their perforators. The flap once placed over the defect always needs to be covered with skin graft.

The basic advantage of adipofascial flaps over fasciocutaneous flaps is that it carries least donor site morbidity as the donior site can be closed primarily.

e. Muscle and musculocutaneous flaps

In 1981 Mathes and Nahi described the classification and clinical application of muscle and myocutaneous flaps. In the lower extremity, local (Gastroenemius, Soleus) or distal (as microvascular transfer of gracilis, Latissimus dorsi, rectus abdominis muscle or musculocutaneous) flaps are available.

The muscles useful for coverage of post traumatic leg defects and the region where their use is recommended include the following:

Proximal third leg defects

- Gastrocnemius
- Skin fascial gastrocnemius

Middle third leg defects

- Soleus
- Flexor digitorum longus

- Peroneus longus
- Tibialis anterior
- Extensor digitorum longus

Distal third leg defects

- Tibialis anterior
- Extensor hallucis longus
- Peroneus brevis
- Soleus

f. Free flaps

In 1973, Daniel and Taylor reported the free transfer of groin, skin and subcutaneous tissue by use of microvascular anastomoses. Commonly used free fasciocutaneous flaps are radial artery forearm flap, dorsalis pedis flap, scapular, parascapular, lateral arm flap, and posterior calf fasciocutaneous flap. Muscle and myocutaneous free flaps commonly used for lower limb reconstruction are latissimus dorsi gracilis, tensor fascia lata and rectus abdominis flaps. Composite osteocutaneous free flaps used for one stage reconstruction and radial artery osteocutaneous flaps, fibula flap and deep circumflex osteocutaneous free flap. It is usually the Grade IIIb

fractures of the legs, and the avulsion and crush injuries of the foot that need free flap cover. The basic objectives in these situations are:

a. Good and early healing of bone

b. Good movement of contiguous joints

c. An aesthetically acceptable stable cover

Advantages

1. Safe vascularity
2. Simple and rapid procedure
3. Applicable in acute as well as chronic wounds
4. Provide stable and pliable soft tissue
5. Allows tendon gliding
6. Can be used as free flap
7. Easy post op care
8. Does not require any special setup or training
9. External fixator does not preclude their use. Future surgery can be performed through them.

Disadvantages

1. Sometimes transfer hair bearing skin

2. Donor site usually hair bearing skin

3. May require to two stages for inferiorly based flap with intervening normal tissue where division of the pedicle is performed under local anaesthesia.

Usual Technical faults

Patient Selection

1. Planning without assessment of local tissue affected by trauma or infection.

2. Poor general conditon, systemic diseases, malnutrition, anaemia, history of smoking and drug addiction.

These conditions may adversely affect the microcirculation

Intraoperative

1. Poor flap planning

2. Failure to identify deep fascia and its incorporation in the flap

3. Failure of suturing the deep fascia to the dermis

4. Coarse tissue handling

5. Locating the pedicle away from the vascular axis

6. Towards the end of the dissection unnecessary undermining of the pedicle by blunt dissection.

7. Twist and kink at the pedicle

8. Suturing under tension

9. Pressure dressing

10. Failure to put a drain under the flap

Postoperative management

1. Frequent monitoring is essential

2. Look for haematoma, evacuate if detected

3. Prevent infection

4. Distal part of the flap should be inspected atleast twice a day and whole dressing needs to be changed alternate day.

Identification of early sings of flap necrosis

1. Lowering of temperature

2. Fine shrinkage of epidermis at the distal part.

3. Discolouration

4. Appearance of small blisters

5. Dark blood on pinprick

Follow up

1. Patient should be taught how to take care of the flap after the patient is discharges, the flap should be inspected by surgeon at least once in fortnight for first three months and thereafter every two months for two years.

3. Gradual weight bearing is allowed 3 months for heel and sole defects

4. The appearance of sensations and their maturity is variable. Usually it starts around 6 months and takes almost two years.

Donor site morbidity

It is usually acceptable to the patients. There is no functional loss. The grafted area gradually becomes soft and supple but seldom matches with the adjacent normal skin.

Disadvantages of fasciocutaneous flaps are

1. Donor site needs to be skin grafted

2. Unlike muscle flaps they cannot fill cantles

It is usually the Grade III b fractures that involve avulsion and crush, that need a free flap cover. The basic objectives in these situations are

1. Good and early healing of bone
2. Good movement of contiguous
3. An aesthetically acceptable stable cover.

First and foremost goal is the management of limit injuries should be to check and establish satisfactory circulation. If planning does not begin at initial evaluation, multiple poorly organised procedures may result in amputation.

REVIEW OF LITERATURE

- ❖ Ponten in 1981 introduced the then new concept of fasciocutaneous flaps, reliably proving, inclusion of deep fascia improved flap survival while allowing an increase in its length breadth ratio.

- ❖ Barclay et al confirmed the validity of Ponten's study with cadaveric dissection and injection studies.

- ❖ Cormack and Lamberty described in detail the arterial anatomy of skin flaps in 1986 classifying Fasciocutaneous flaps into

Type A - Multiple fasciocutaneous vessels entering the base and oriented along its long axis.

Type B- Single Fasciocutaneous perforator consistently present

Type C- Multiple perforators passing along a fascial septum septocutaneous perforators.

Type D- Osteomyofasciocutaneous flap.

- ❖ Trenkic's. et al used fasciocutaneous flaps between 1966-2003 for leg defects in 69 patients. They were either proximally or distally based or islanded and based on septocutaneous perforators of all 3 main arteries of the lower leg. The author reports flap loss in only 4 patients. He found these flaps reliable even in war wounds and even in the distal third.

- It was surprising, as corroborated by Dickson et al that even in the presence of osteomyelitis, at least short term wound healing with these flaps was possible.

- Marko Godina in 1980 introduced and developed the concept of Emergency free tissue transfer.

- As early as in 1901, Ponteau reported the use of fasciocutaneous flaps in lower leg.

- All of Ponten's flaps were proximally based, raised in a single stage and measured upto 18 cm x 8cm.

- In contrast to Ponten, Barclay in 1982 and Amarante in 1986 used distally based fasciocutaneous flaps based on lower perforators of the posterior tibial and peroneal arteries.

- Laughlin et al reviewed the functional outcome in eight patients with grade IIIB, and six with Grade IIIC injuries and found out that the recovery period was long.

- Byrd et al. found that the overall complication rate for wounds closed within the first week of injury was 18% compared to 50% complication rates for wounds closed in the subacute phase of 1-6 weeks.

- Godina et al found that the least complication rates were in wounds closed within 72 hours of injury.

- Yaremchuk et al postulated that serial, complete debridement is more important than timing of soft tissue coverage.

- Platelet counts increase four fold in the subacute phase after injury contributing to increased complication rate according to Choe IE et al.

- Trabulsy and Tornetta showed that non reamed locked nails combined with early soft tissue cover was more effective than external fixation.

- Hallock in a series of 67 consecutive fasciocutaneousflaps found an 18.5% complication rate with distally based flaps having 37.5% complication rate.

- Local fasciocutaneous flaps obtained ultimate wound closure in 97% of patients.

- May reviewed a 13 year experience of treating chronic traumatic bone wounds with free flaps and had a 95% success rate in his series of 96 patients.

- It is recommended that immediate coverage or coverage within 72 hours is preferable to repeat debridements over a longer period as

marginal tissues that dessicate with time might be saved with immediate coverage.

- Immediate coverage and early coverage within 72 hours permit salvage of large fragments eliminating need for bone grafting.

- Advantages of acute coverage include shorter hospital stay, less pain associated with dressing change, decreased infection rate and superior long term results (MC Carthy Plasticsurgery 1990).

- In the setting of damaged periosteum, the surrounding soft tissue becomes the source of blood supply to the healing fracture. Delayed healing of displaced tibial fractures therefore is related to the subcutaneous location of the tibia and the resultant paucity of surrounding soft tissue.

- The use of tissue expansion in the lower extremity has not been embraced by plastic surgeons as it has been in other areas of the body, such as the breast and scalp. The potential advantages of using expanded skin in the lower extremity over other reconstructive methods and include improved contour, coverage with like tissue and improved aesthetic result. It is generally useful for healed, chronic defects and placement near open wounds results in more complications (Borgest et al).

- Flap prefabrication with tissue expansion may have a role to play in expansion of the medial side of the opposite leg before crossleg transfer (Mathes, Plasticsurgery - 2006).

- Byrd et al described acute, subacute and chronic phases of open tibial fractures Ideally the wound is covered in the first 5-6 days after injury the acute phase. Colonised wounds and a higher propensity to infections and flap failures characterised the subacute phase between 1-6 weeks after injury. Between 4 and 6 weeks, the wound enters a chronic phase characterised by robust granulation tissue, adherent soft tissue and clear demarcation between viable and non viable bone.

- In Emergency free tissue transfer for open tibial fractures Marko Godina in 19 reported 0.75% flap failure, 1.5% infection rates when reconstructed with 72 hours.

- This is compared with 12% flap failure, 17.5% infection when reconstructed between 72 hours and 3 months of injury.

- Those reconstructed beyond 3 months had a flap failure rate of 9.5% and infection rate of 6%.

- The most important step in the surgical treatment of osteomyelitic tibial is thorough debridement of all devascularised and contaminated tissue, including bone, granulation tissue, and the

scarred surrounding soft tissue. Subsequent management of the bone defect may be achieved with bone grafting, vascularised free bone transfer, or bone distraction (Lin et al).

- ❖ Ponten noted the survival of posterior and calfskin in a boy with electrical injury with an angiogram showing only one unoccluded small superficial posterior central artery arising from the popliteal artery. The inspired him to perform a proximally based flap on the calf, including the deep fascia with sural nerves and vessels. His land mark description of a proximally pedicled fasciocutaneous flap prompted numerous varieties of fasciocutaneous flaps to be developed. Distally based faciocutaneous flaps are especially useful as an alternative to free tissue transfer in coverage of distal third leg and ankle defects.

- ❖ The sural artery flap provides potentially the longest fasciocutaneous flap of the lower leg. It is useful for defects of the knee, popliteal fossa and upper third of the leg. It can be distally based and used as reverse flap for lower 1/3 and middle 1/3 defects (Lamberty BGH).

- ❖ Fabio and Sontanelli in their study have shown the most frequent causes of lower extremity trauma are

1. Motor cycle accidents -28%
2. Vechicle accident -24%

3. Pedestrian accident - 12%
4. Domestic accident - 13%
5. Firerm accident - 2%
6. Work and sport related - 13%
7. Crushing injuries - 8%

- ❖ Trentz-O et al have described the priorities in treatment of open tibial fractures in the order of

1. Resuscitation
2. Restoration of vascularity
3. Debridement
4. Skeletal stablisation
5. Second look debridement
6. Coverage with a local or free muscle flap within 96 hours.
7. Reconstruction of bone defect by bone grafting, callus distraction or bone segment transports with unilateral fixators.

- ❖ Kozarski et al have described, the specificity of the lower leg with respect to the difference in blood flow owing to sparse collateral flow to the skin in the middle and distal parts, decreased subcutaneous tissue and the fact that the tibia lies immediately under the skin of the shin making certain flaps impossible in the lower leg.

- Perphaps the biggest series belongs to Berger A et al with greater than 5000 skin transplantations, 3000 local flaps, 200 distant flaps and 1200 free tissue transfer between 1981 to 1995. They came to the conclusion that new and old concepts should be integrated as a whole into the treatment schedule.

- Graf P et al found distally based fasciocutaneous flaps to be an alternative for free flaps.

- Sharma GN, Nepran S.S. have used the distally based sural artery fascio - cutaneous flap for moderate sized defects of the lower leg and foot in 12 cases and found it to be dependable.

- This flap was based on the median superficial sural artery and its communication with the perforating branch of the peroneal artery situated in the region of the lateral malleolar gutter.

- Reverse flow is established with division of the sural artery and nerve proximally.

- A study from Scotland presented 7 patients covered for open tibial fractures with cover within 3 days. 2 patients had partial distal necrosis of the flap but were salvaged.

- Cross leg flaps were presented in a study from Central Hospital, China. 23 cases were successfully treated with no infection and flap loss.

- Kaplan I et al found that in a study of 28 patients between 1988 - 1996 covered with free flaps that flaps were lost in 12% only, patients needed a single stage reconstruction only, with decreased infection and an earlier return to active life.

- Neale, Stan et al. found in a study of 95 consecutive muscle flap procedures performed on 71 patients with traumatic soft tissue defects of the leg that there were 5 cases of total flap reconstruction and other major and minor complications in 31 patients requiring additional surgery for coverage.

- Because they are less bulky, they are indicated when thin flaps are needed. Unlike muscle flaps no functional loss occurs. e.medicine. com. Kerriwood berry.

- Tolhurst, Haesekar and Zeeman demostrated 15% greater survival length in flaps that included fascia.

- Cierny. G. Jones RE et al analysed 36 Type III and IIIa open fractures of the tibial shaft and presented a treatment protocol based on early, aggressive wound management and fracture coverage using muscle, myocutaneous, or free flaps. There were 5 amputations, 7 deep infections, 3 non-unions and no cases of chronic osteomyelitis. Wound coverage was classified as early or late (0-7 days and 8-30 days respectively).

Major and minor wound healing disturbance was found in 20.8% of early and 83.3% of late groups.

- Karacaoglan, H. Velidedeoglu presented 7 patients with extensive middle 3rd defects of the lower leg where 2 different flaps were used to cover the defect and all cases were reconstructed successfully (European Journal of Plastic Surgery 18; 1:43-45).

OBSERVATION AND RESULTS

A total number of 74 patients were included in the study over a period of 30 months between August 2004 to Janurary 2007.

INCIDENCE - YEARLY

1.	Aug 2004- Dec 2004 -	12
2.	Jan 2005 - Dec 2005 -	40
3.	Jan 2006 - Jan 2007 -	22

There was a noticeable difference in the number of cases in the last year owing to a higher number of muscle flaps being done for upper 1/3 leg defects as part of a change in department protocol

AGE AND SEX INCIDENCE

Age Group	Male	Female
1. < 12years	9	1
2. >12 years	58	6

Though this was for a series of fasciocutaneous flaps only, it reflected the overall incidence of traumatic leg defects in general, with the adult male population being the most at risk 78%.

ETIOLOGICAL INCIDENCE

Sl.No	Cause	Number
1.	Road Traffic Accident	62
2.	Train Traffic Accident	4
3.	Fall from Height	8

The etiological indications for fasciocutaneous flap cover in this study showed Road traffic incidents to be the most common cause at 84%.

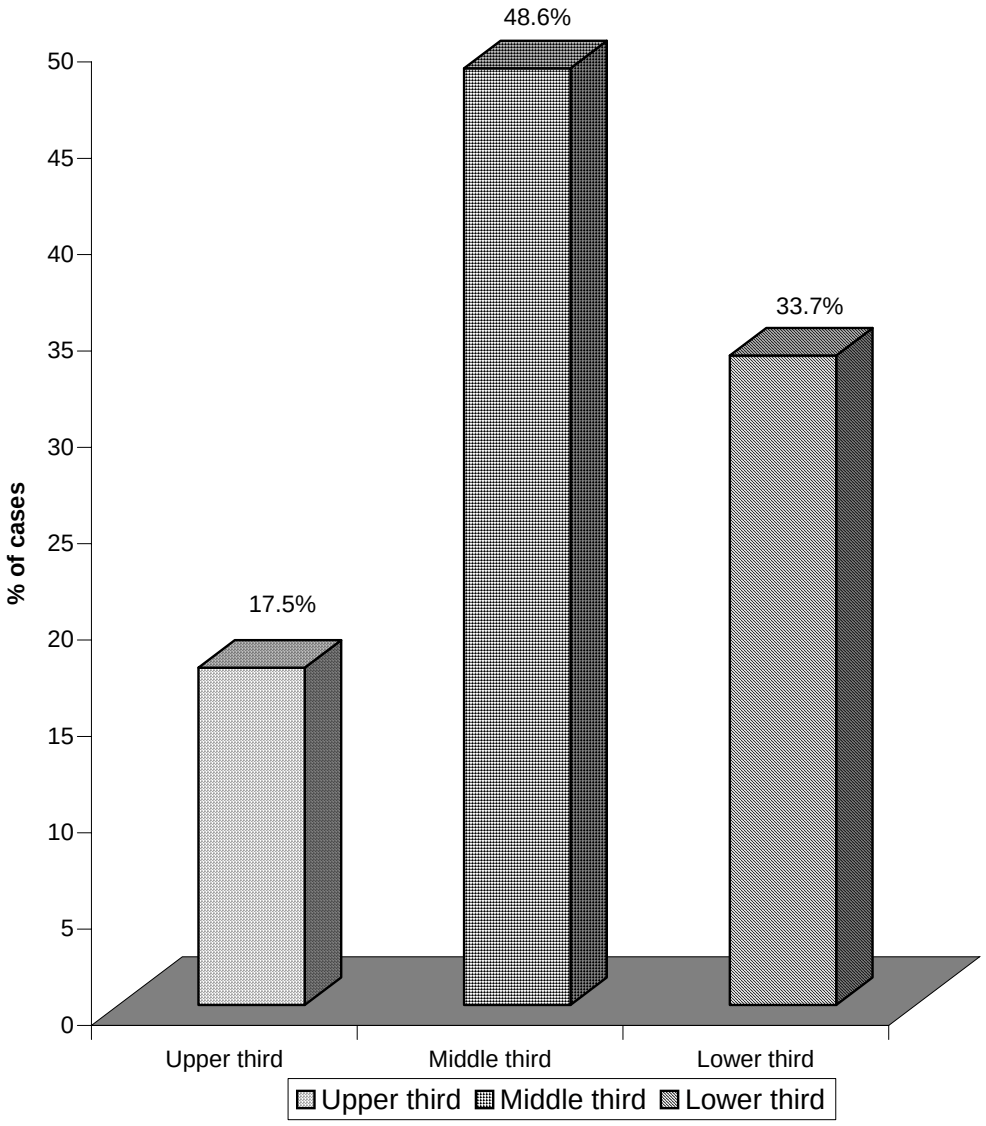
SITE OF INJURY

Sl.No	Site	No.of cases
1.	Upper third	13
2.	Middle third	36
3.	Lower Third	25

Thus fasciocutaneous flaps in this study were most commonly used for middle third leg defects 48%, followed by lower third 34% and upper third 18%.

This fact co-relates well with the fact mentioned in table 1 that the overall incidence of usage of fasciocutaneous flaps for upper third defects has decreased at Government General Hospital.

SITE OF INJURY

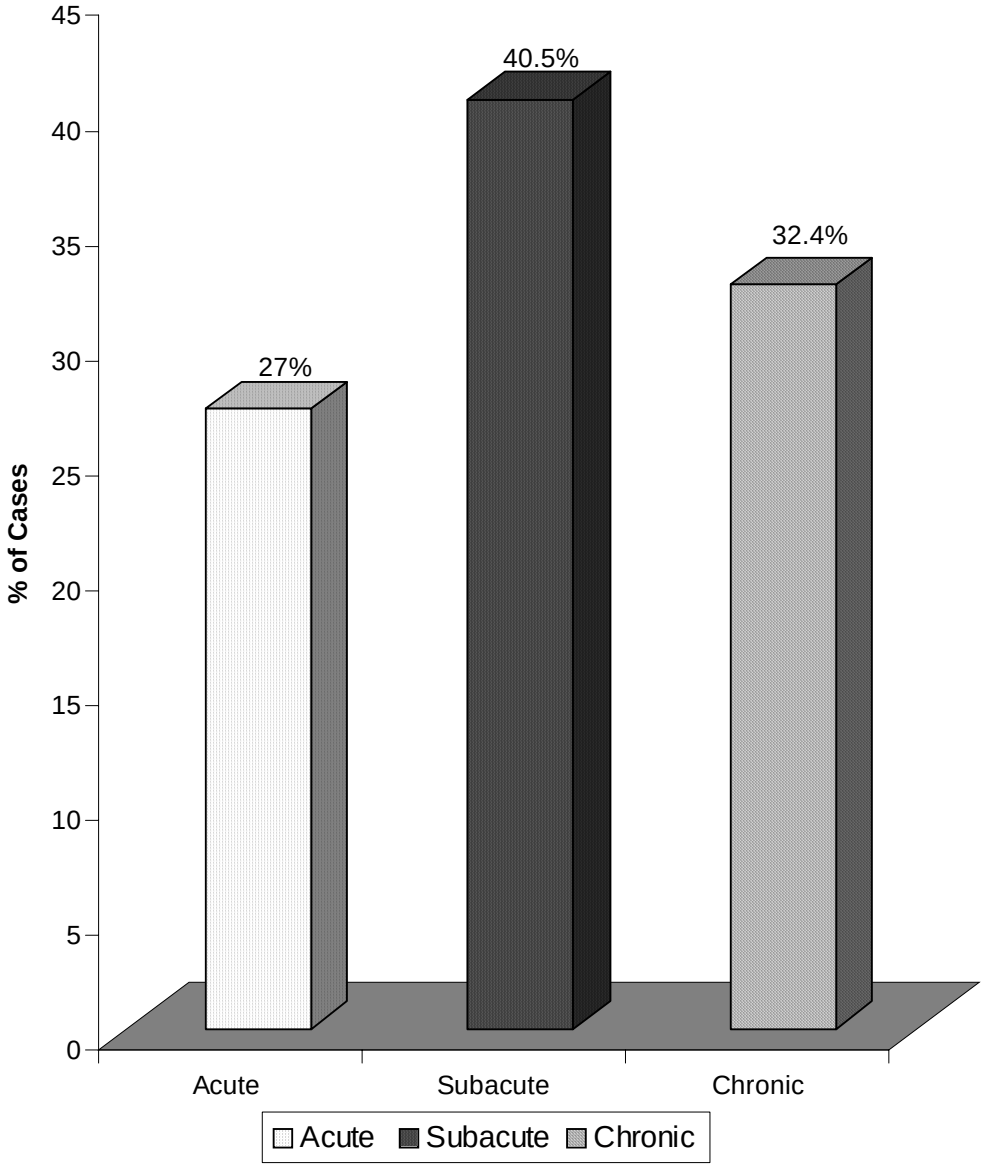


PHASE OF COVERAGE

Sl. No	Immediate Action	No. of cases
1.	Acute (within 72 hours)	20
2.	Subacute (72 hours - 6 weeks)	30
3.	Chronic (beyond 6 weeks)	24

In this series maximum number of fasciocutaneous flaps were done in the subacute phase - 41% and the least in the acute phase 27%.

PHASE OF COVERAGE

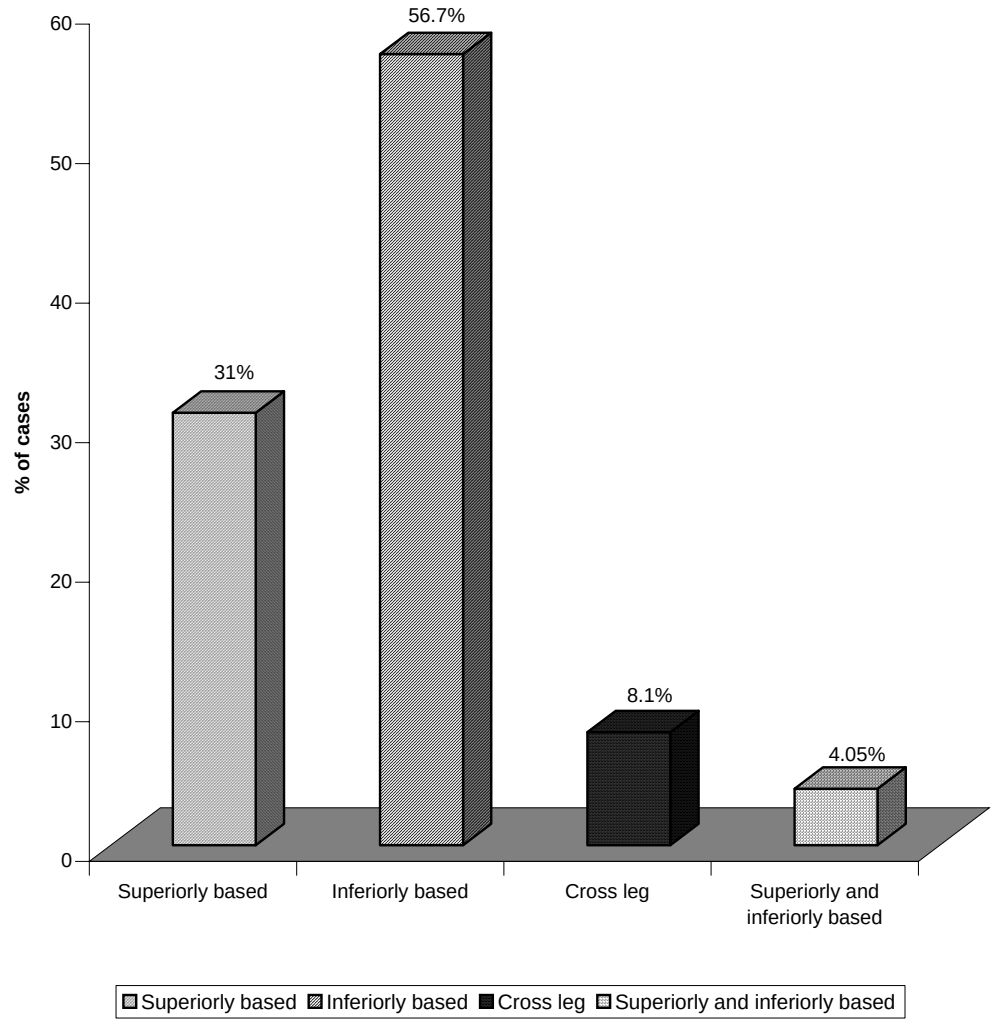


TYPE OF FASCIOCUTANEOUS FLAP COVER

Sl. No	Type	Number of cases
1.	Superiorly based fascio cutaneous flaps	23
2.	Inferiorly based fascio cutaneous flaps	42
3.	Cross leg fascio cutaneous flaps	6
4.	Superiorly and Inferiorly based dual flaps	3

Inferiorly based fasciocutaneous flaps were the most commonly used in this study accounting for 56% of all flaps and, dual superiorly and inferiorly based flaps were the least commonly needed.

TYPE OF FASCIOCUTANEOUS FLAP COVER



MODE OF SKELETAL STABLISATION

Sl.No	Type	No.of cases
1.	External Fixators	69
2.	Internal Fixators	5

The orthopaedicians preferred mode of skeletal stablisation was external fixation in 93%

COMPLICATIONS OF VARIOUS TYPES OF FLAPS

Sl. No.	Flap type	Infection	Partial Flap loss	Total
1.	Superiorly based fasciocutaneous flaps	3	6	Nil
2.	Inferiorly based fasciocutaneous flaps	10	3	1
3.	Cross leg flaps	1	Nil	1
4.	Superiorly and inferiorly based fasciocutaneous flaps	1	Nil	Nil

Infection was the most common complication in this series, it was managed by conservative measures - Appropriate antibiotics / Irrigation, but one case necessitated a sequestrectomy in the operation theatre.

Partial flap loss was managed in 2 ways

1. Where bone was not exposed, wound was allowed to granulate after removing the necrosed part and covered with split skin graft.

2. Where bone was exposed, the patient was taken to the operation theatre and the flaps were adjusted after shifting the pedicle further proximally or distally as needed.

Total flap loss in 2 cases were covered with a medial gastrocnemius muscle and skin grafted

COMPLICATIONS DURING VARIOUS PHASES OF COVER

Sl. No.	**Phase**	**Complications**		
		Infection	Part Loss	Total Loss
1.	Early	2	Nil	Nil
2.	Subacute	12	7	2
3.	Chronic	1	2	Nil

Complications were greatest in the subacute phase - 28% of all cases with the chronic cases surprisingly mirroring the early phase in contradistinction to other studies, perhaps owing to adequate preparation with repeat debridements, sequesttrectomies, antibiotic cover and wound homeostasis in the interim period with adequate skeletal stabilisation.

DISCUSSION

An analysis of the study resulted in the following points to ponder.

INCIDENCE

Though a fair number of fasciocutaneous flaps require to be done in our department at GGH, there may be a shift towards the use of muscle flaps upper 1/3 defects owing to decreased donor site morbidity.

This parallels the study results of muscle flaps where they were found to have less donor site morbidity, Increased oxygen tension under them and decreased bacterial count.

AGE

In this study the age of the patients varied from 9 years to 80 years with the mean age 40 years. This is almost 5 years more than in the series of Suri MP et al (25-35 years mean age).

SEX

Open tibial fractures, needing fasciocutaneous flaps are almost similar to the over all sex incidence of open tibial fractures.

In this study 78% of those operated on were males while other studies have quoted 64% (Akthar 8 et al).

Males may be more commonly affected owing to their increased mobility, usage of two wheelers and ingestion of alcohol.

ETIOLOGY

In concordance with Fabio and Santanelli, Road traffic accidents continue to be the major cause of open tibial fractures in a developing country like ours just as in the developed nations.

A better adherence to road rules, stricter licensing laws and a curb on drunken driving could decrease the incidence of open tibial fractures.

SITE

In this study Fasciocutaneous flaps were most commonly used for middle third defects 48%.

Middle third defects were also the most common defects in our total number of patients with open tibial fractures.

With increasing use of muscle flaps with skin grafting for upper third defects the indication for fasciocutaneous flaps for upper third defects is less - 18%.

PHASE OF RECONSTRUCTION

Most number of cases were operated on for cover at the subacute phase 40% and in the chronic phase 32% with the least number in the acute phase 28%.

This is in total contrast to literature elsewhere where early cover is recommended. (Godina et al, Byrd et al).

The reasons for the decreased immediate cover were,

1. Co existing head injury taking priority for management.
2. Lack of immediate referral by orthopaedicians.
3. Shortage of plastic surgery team members.
4. Doubtful vascularity of the limb.
5. Co existing wounds on the leg requiring skin grafting.
6. Co morbid illnesses with patients on Aspirin for ischaemic heart disease.
7. Delayed skeletal stabilisation where internal fixation was used.
8. In 1 patient who was HIV positive as adequate protective gear was not available.

Type of Fasciocutaneous Flap Cover

Though the site of the defect and the status of the adjourning tissues decided the type of flap in our study, most fasciocutaneous flaps were inferiorly based 56%.

This is in contrast to Ponten who used only proximally based fasciocutaneous flaps.

MODE OF SKELETAL STABILISATION

Almost 93% of patients in this study were stablised with external despite conclusive studies by Trabulsy et al fixators et al proving non-reamed locked nails were more effective than external fixators.

Again this may reflect availability rather than personal preference.

COMPLICATIONS

1. The overall incidence of complications in this series of fasciocutaneous flaps was 33.5% which is higher compared to Hallock's series which had a complication rate of 18.5%.

2. Distally based fasciocutaneous flaps had a higher complication rate than others in contrast to Hallock's series.

3. Infection was the most common complication - 60% of all complications.

4. Total flap loss was seen in only 2 patients which indicated a successful wound coverage in 97%.

   This was similar to Hallock's series in which local fasciocutaneous flaps obtained ultimate wound closure in 97%.

This also compared very favourably with May's series with free flap coverage which had a overall success rate of 95% in coverage of open tibial fractures.

TIMING OF COVER

Complication rate was least in those case given early cover - 10% Complication rate was highest in the subacute phase - 70%.

Surprisingly in chronic cases the complication rate was only 12.5%.

The complication rates for the acute and subacute phases were in keeping with Byds's series where he had complication rates of 18% and 50% respectively.

FREE FLAPS V/S FASCIOCUTANEOUS FLAPS

In comparison to Godinas series the following observations were seen

	Study		**Godinas series**	
	Infection	**Flap loss**	**Infection**	**Flap loss**
Early phase	10%	Nil	1.5%	0.75%
Subacute phase	40%	30%	17.5%	12%
Chronic phase	4%	8%	6%	9.5%

This once again emphasises the need for early cover.

There was a significantly higher infection rates in the early phase and subacute phase with fascio cutaneous flaps than microvascular free flaps probably due to the improved oxygen tension and decreased bacterial count under muscle.

There was no difference in the infection rates in chronic cases with the fasciocutaneous flaps having lesser infection. This may be due to the quiescence in the tissues/adequate antibiotic cover, established stability of the skeleton, the necessity to dissect for a donor vessel in the free flaps.

Flap loss rates were significantly higher in the subacute phase in comparison to free flaps but again there was no significant difference in the chronic phase probably owing to the same reasons as above.

CONCLUSION

1. Fasciocutaneous flaps are reliable, safe, fast to learn flaps for leg defects.

2. Males continue to be at high risk for compound tibial fractures particularly from Road traffic accidents. Stricter road safety protocols, safer roads, strict licensing could perhaps decrease the incidence of open tibial fractures.

3. Fasciocutaneous flaps have shown a decrease in their use for upper third defects, but continue to be a bulwark for the middle third defects.

4. Though muscle flaps have taken priority in upper third defects, fasiocutaneous flaps were very useful still in lower third defects as free tissue transfer was not done in our hospital during the period of the study.

5. Most cases in this study were operated on in the subacute phase which had the highest complication rates also indicating the need for early referral by the orthopaedician, a combined team approach, and involvement of the plastic surgeon in the planning of the case from the trauma ward itself.

6. The fact that there was no difference between free flaps and fasciocutaneous flaps in terms of flap loss in the early and chronic

phases indicate that the fascioutaneous flaps can be safely done in the emergency sitting, where facilities for microsurgical transfer are not available, with the added advantage of decreased operating time. No necessity for two teams and no alterations in the hematological parameters.

7. Successful wound coverage results were the same as for free tissue transfer in other studies.

8. Flap coverage is best done within 72 hours of injury.

MASTER CHART

Sl. No.	Age/Sex	Site of Defect	Type of Fixation	Flap used	Phase of Cover	Complication		
						I	PFL	TFL
1.	55/M	M1/3	EF	SB	Chronic			
2.	32/M	M1/3	EF	SB	Subacute		✓	
3.	49/M	U1/3	EF	IB	Subacute			
4.	49/M	L1/3	EF	SB	Subacute		✓	
5.	72/M	L1/3	EF	IB	Subacute			
6.	30/M	U1/3	EF	IB	Subacute			
7.	9/Mch	M1/3	EF	IB	Acute	✓		
8.	40/M	M1/3	EF	CL	Subacute	✓		
9.	42/M	L1/3	IF	IB	Acute			
10.	42/M	M1/3	EF	SB	Chronic			
11.	11/M	U1/3	EF	IB	Chronic		✓	
12.	11/M	U1/3	EF	IB	Chronic			
13.	56/M	U1/3	EF	DF	Subacute	✓		
14.	34/M	L1/3	EF	SB	Subacute	✓		
15.	38/M	L1/3	EF	SB	Subacute			
16.	44/M	M1/3	EF	IB	Chronic			
17.	12/M	M1/3	EF	IB	Subacute			
18.	44/M	L1/3	IF	IB	Chronic			
19.	38/M	U1/3	EF	SB	Acute			
20.	26/M	L1/3	EF	IB	Chronic			
21.	24/M	M1/3	EF	IB	Subacute			✓
22.	26/M	M1/3	EF	SB	Subacute	✓	✓	
23.	38/M	M1/3	EF	CL	Subacute			✓
24.	59/M	L1/3	EF	IB	Chronic			
25.	40/M	M1/3	EF	SB	Acute			
26.	55/M	M1/3	EF	IB	Subacute			
27.	19/M	U1/3	EF	SB	Acute			
28.	40/M	L1/3	EF	IB	Acute	✓		

Sl. No.	Age/Sex	Site of Defect	Type of Fixation	Flap used	Phase of Cover	Complication		
						I	PFL	TFL
29.	29/M	L1/3	EF	CL	Subacute			
30.	37/M	L1/3	EF	IB	Chronic			
31.	22/M	M1/3	EF	SB	Subacute	✓	✓	
32.	55/M	U1/3	EF	SB	Subacute	✓	✓	
33.	60/M	U1/3	EF	IB	Chronic			
34.	40/F	L1/3	EF	DF	Chronic			
35.	26/F	M1/3	EF	IB	Acute			
36.	28/M	L1/3	EF	CL	Subacute	✓		
37.	30/M	M1/3	EF	SB	Chronic			
38.	11/Fch	M1/3	EF	IB	Acute			
39.	31/M	U1/3	EF	IB	Chronic			
40.	40/M	U1/3	EF	SB	Chronic			
41.	70/M	M1/3	IF	SB	Acute			
42.	49/M	U1/3	IF	DF	Acute			
43.	31/M	U1/3	EF	IB	Chronic		✓	
44	12/M	M1/3	EF	SB	Chronic			
45.	25/M	U1/3	EF	IB	Subacute	✓		
46.	24/M	M1/3	EF	IB	Subacute			
47.	40/M	L1/3	EF	CL	Chronic			
48.	19/M	M1/3	EF	SB	Chronic	✓		
49.	11/M	M1/3	EF	SB	Acute			
50.	39/M	U1/3	IF	IB	Subacute		✓	
51.	38/M	L1/3	EF	SB	Chronic			
52.	70/M	M1/3	EF	IB	Acute			
53.	64/M	M1/3	EF	IB	Subacute	✓		
54.	41/F	L1/3	EF	IB	Acute			
55.	10/M	M1/3	EF	IB	Subacute			
56.	22/M	M1/3	EF	IB	Chronic			
57.	24/M	L1/3	EF	IB	Acute			
58.	12/M	M1/3	EF	CL	Subacute	✓		
59.	38/M	M1/3	EF	IB	Chronic			

Sl. No.	Age/Sex	Site of Defect	Type of Fixation	Flap used	Phase of Cover	Complication		
						I	PFL	TFL
60.	38/M	M1/3	EF	SB	Acute			
61.	26/M	L1/3	EF	IB	Subacute	✓		
62.	29/M	L1/3	EF	SB	Acute			
63.	49/M	M1/3	EF	SB	Subacute		✓	
64.	44/M	L1/3	EF	IB	Chronic			
65.	36/M	L1/3	EF	IB	Acute			
66.	22/M	M1/3	EF	IB	Acurte			
67.	22/M	M1/3	EF	IB	Chronic			
68.	36/M	M1/3	EF	IB	Subacute	✓		
69.	37/M	L1/3	EF	SB	Subacute			
70.	52/M	M1/3	EF	SB	Chronic			
71.	56/M	M1/3	EF	IB	Acute			
72.	38/M	M1/3	EF	IB	Acute			
73.	70/M	L1/3	EF	SB	Subacute			
74.	24/M	M1/3	EF	IB	Subacute			

KEY TO MASTER CHART

U1/3 - Upper Third
M1/3 - Middle Third
L1/3 - Lower Third
M - Male
F - Female
FCh - Female Child
Mch - Male Child
EF - External Fixator
IF - Internal Fixator
SB - Superiorly based
IB - Inferiorly based
CL - Cross leg
DF - Dual flap
I - Infection
PFL - Partial flap loss
TFL - Total flap loss

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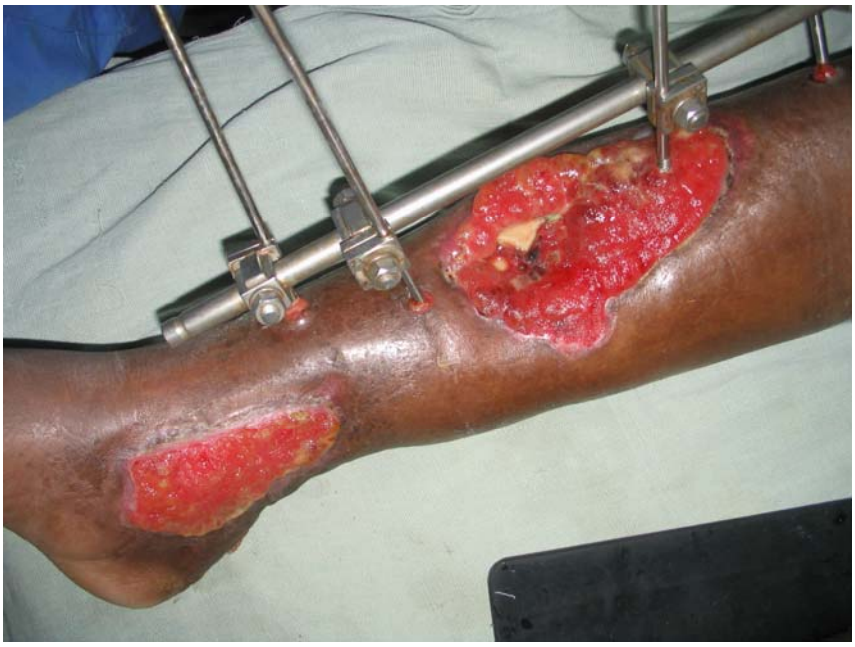
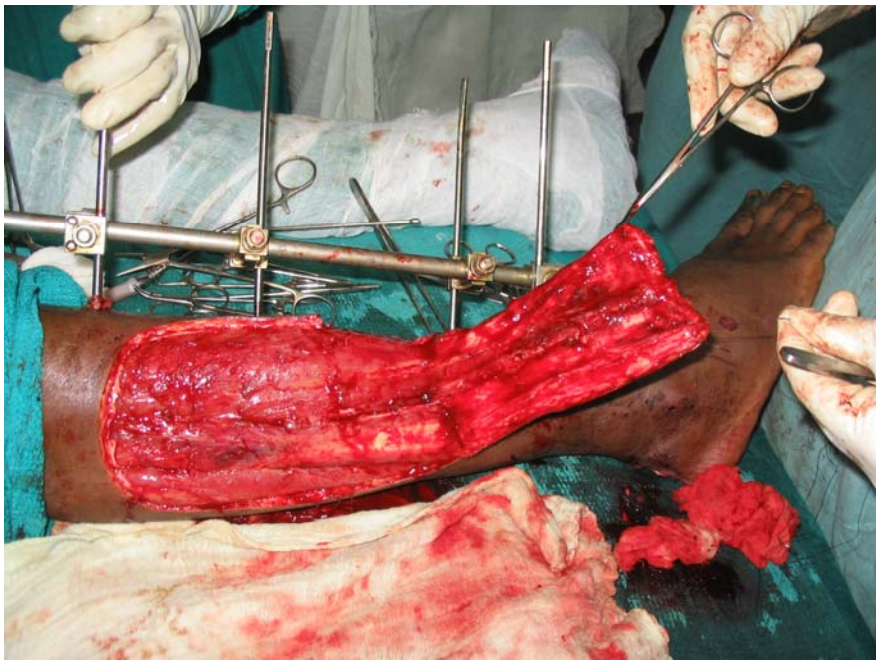
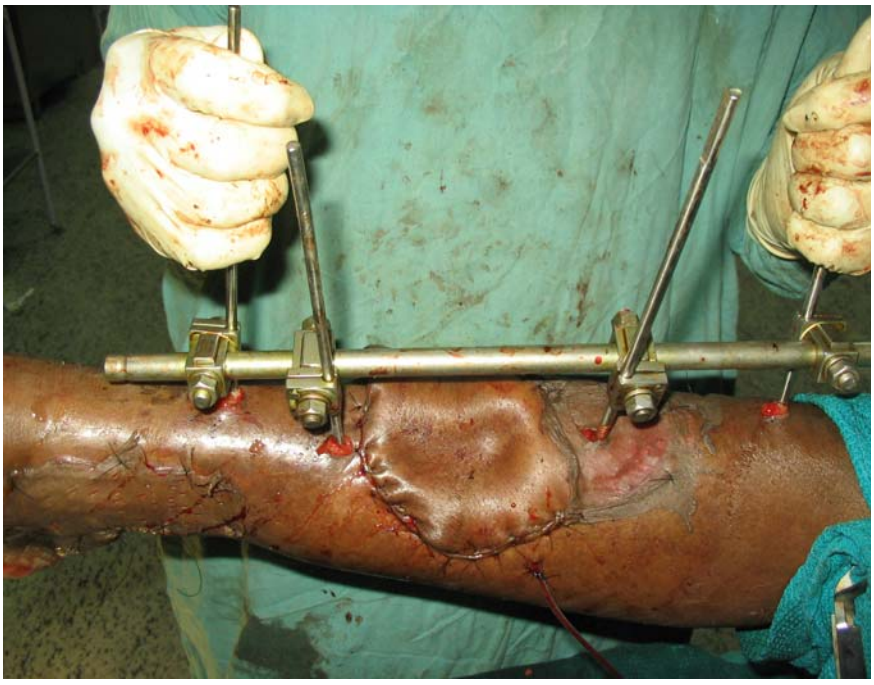
DEFECT MIDDLE THIRD LOWER THIRD JUNCTION



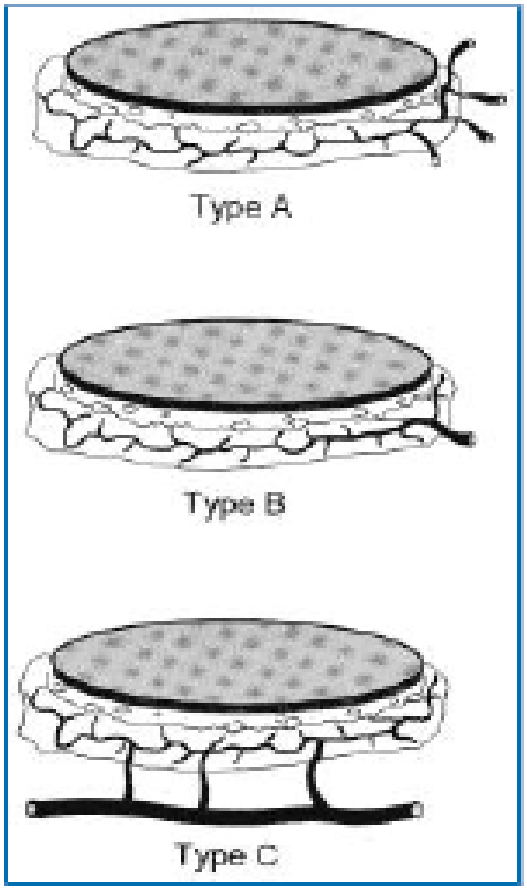
INFERIORLY BASED FASCIOCUTANEOUS FLAP



FLAP IN PLACE



DEFECT MIDDLE THIRD LOWER THIRD

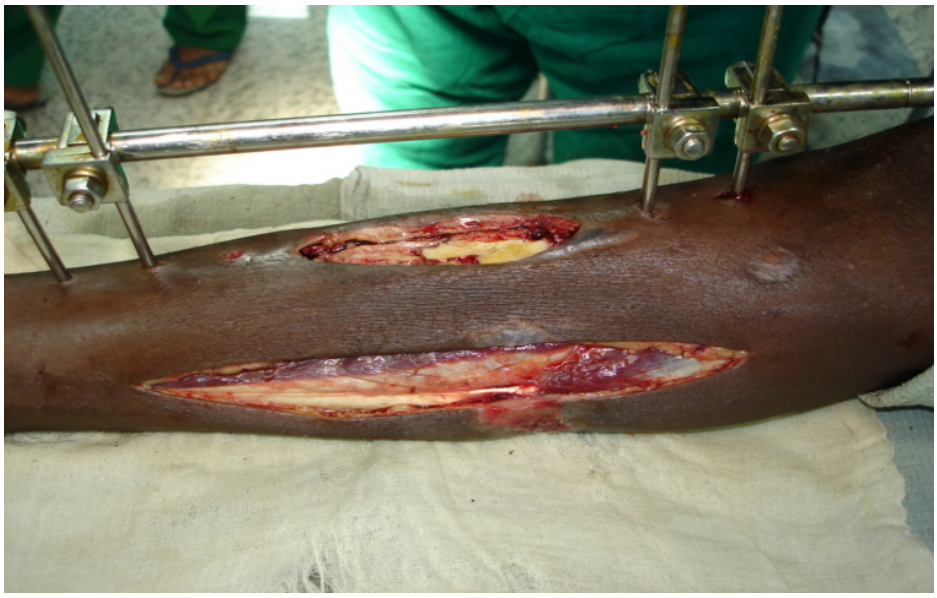


Fasciocutaneous flap subtypes according to their source of fascial perforators: *type A,* multiple perforators (Pontén-type);*type B,* solitary, discrete perforator; *type C,* multiple segmental perforators all arising from a single underlying deep source vessel. (Modified from Hallock, G. G. Complications of 100 consecutive local fasciocutaneous flaps. *Plast. Reconstr. Surg.* 88: 264, 1991.)

DEFECT UPPER THIRD

DUAL FLAP

BIPEDICLE FLAP



BIPEDICLE FLAP IN PLACE